Background

The present invention generally relates to methods and apparatuses for adding slurry to a semiconductor wafer polishing system, and more specifically relates to a method for adding slurry using a moveable outlet, such as one or more moveable arms, in a semiconductor wafer polishing system.

An IC chip is a sandwiched, multiple layer structure which typically includes a silicon substrate, dielectric layers, metal interconnects, devices and so on. Every layer is formed by deposition, photolithographic, etching, as well as other, techniques. Every layer must be planar and, as the features get smaller, the requirement for planarity gets more stringent. Chemical Mechanical Polishing (CMP) plays an important part in planarizing every layer before the next top layer is deposited. The CMP process involves pressing the face of the wafer to be polished against a compliant polymeric polishing pad and generating relative motion between the interface between the wafer and the pad. A slurry consisting of abrasives and chemicals is fed in between the interface between the wafer and the pad. The combined chemical action of the chemicals in the slurry and the mechanical action of the abrasives cause material to be removed from the wafer. A typical CMP setup looks very similar to a lapping machine, but the precision is much higher and there is a lot more sophistication.

One of the most commonly-used devices for polishing a semiconductor wafer is a rotational format CMP machine as illustrated in Figure 1. The wafer 10 is held in a wafer carrier 12, and is pressed against a polishing pad 14 which is disposed on a polishing table 16. Both the wafer carrier 12 and polishing table 16 are then rotated (as indicated by arrows 18 in Figure 1), and slurry is supplied on the pad 14 via a stationary slurry dispense line 20. The stationary slurry dispense line 20 is used to drip slurry 22 on the pad 14 in front on the wafer 10. The process can be manipulated by either increasing or reducing the slurry flow, but this is not very stable, and does not provide much control.

In CMP processing, there is a need to control the removal rate of the material being polished across the wafer. The need to improve the control is due to many different reasons, including: non-uniformity introduced in preceding steps, non-uniformity inherent in the CMP process, and the need to tailor the output to match the needs of a downstream process. An additional key need is to reduce the cost and defects of the CMP process.

Many different ways have been attempted to change the process uniformity, including: zone adjusting on the process head (wafer carrier); changing the down force and RPM's of the wafer carrier; changing the offset of the wafer with respect to the retaining ring; and changing the radius that the slurry is added to the platen. Each of the methods which have been attempted have problems. For example, zone adjusting is limited to the maximum that the head will permit. In some cases, more is needed. While this is currently the best widely-used method, it can be expensive to add to a tool. With regard to changing the down force and RPM's of

the wafer carrier, only a very small adjustment is possible without reducing the rate of the process. With regard to changing the offset of the wafer with respect to the retaining ring, this can only affect the outer few millimeters of the wafer. It is also a hardware adjustment which cannot be easily and quickly adjusted (i.e., "on the fly"). It requires changing a major part of the tool.

Objects and Summary

An object of an embodiment of the present invention is to provide a method and apparatus which allows a CMP process to be more accurately controlled.

Another object of an embodiment of the present invention is to provide a method and apparatus which provides better control over the profile of the polish in a CMP process.

Still another object of an embodiment of the present invention is to provide a method and apparatus which allows less slurry to be used in a CMP process.

Yet another object of an embodiment of the present invention is to provide a method and apparatus which reduces the amount of defects in a CMP process.

Yet still another object of an embodiment of the present invention is to provide a method and apparatus which provides less dilution of the slurry when purging the line in a CMP process.

Briefly, and in accordance with at least one of the foregoing objects, an embodiment of the present invention provides a method and apparatus for adding slurry using a moveable outlet, such as one or more moveable arms, in a semiconductor wafer polishing system. The end of the slurry arm could be set to fan out the slurry as the slurry is dispensed onto the pad. Preferably, the arm is set so that the distance and centering of the arm is controlled by the setup of the process. The arm could be set to move in an arc, or to move in and out on a set track. Regardless, the slurry is preferably sprayed onto the pad in the location needed to place the slurry on the pad, but only in the areas that are needed. This increases the control of the uniformity of the process, and preferably reduces the

total amount of slurry that is used in the process.

Brief Description of the Drawings

The organization and manner of the structure and operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawing, wherein:

Figure 1 illustrates a prior art rotational format CMP machine;

Figure 2 illustrates a CMP machine which is in accordance with an embodiment of the present invention; and

Figure 3 is a block diagram of a method which is in accordance with an embodiment of the present invention, wherein the CMP machine illustrated in Figure 2 is used to polish a wafer.

Description

While the invention may be susceptible to embodiment in different forms, there is shown in the drawings, and herein will be described in detail, a specific embodiment with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that as illustrated and described herein.

Figure 2 illustrates a CMP machine which is in accordance with an embodiment of the present invention. As shown, the machine includes a wafer carrier 12 for holding a wafer 10, wherein the wafer carrier 12 presses the wafer 10 against a polishing pad 14 which is disposed on a polishing table 16. Both the wafer carrier 12 and polishing table 16 are then rotated (as indicated by arrows 18 in Figure 2), and chemical such as slurry 22 is supplied on the pad 14 via one or more moveable slurry dispense outlets 32 (two are shown in Figure 2).

As shown in Figure 2, each moveable slurry dispense outlet 32 may be a line 36 on a moveable arm 38, where the moveable arm 38 is configured to be moved in an arc (represented in Figure 2 by arrows 40) or in and out on a set track (represented in Figure 2 by arrows 42). Each of the outlets 32 can be configured to dispense an appropriate slurry or other chemical, depending on the process and application. Each moveable arm 38 could be set so that the distance and centering of the arm 38 is controlled by the setup of the process. As discussed above, this could be based on the arm swinging in an arc or moving in and out on a set track.

Figure 3 shows the steps of the process when the CMP machine shown in Figure 2 is used to polish a wafer. During the process, preferably slurry is only sprayed where and when it is needed, thereby increasing the control over the uniformity of the process, reducing the total amount of slurry which is used, reducing the overall cost of the process, and reducing the amount of defects (i.e., due to the arm(s) being off the pad when it is being purged, thereby keeping old dry slurry from being purged onto the pad). Additionally, there is less dilution of the slurry when purging from the line, as the purging can be performed over the side of the pad, and not on the process area.

More than one moveable arm could be employed in the process, and more than one type of slurry can be used, or water or a pH buffer (that is the same as the slurry) can be used to dilute the slurry at the point of use without changing the pH which is very important for the process. The end of the arm could also be configured to fan out the slurry as it is dispensed onto the pad, thereby reducing the amount of slurry which is needed in the process.

While an embodiment of the present invention is shown and described, it is envisioned that those skilled in the art may devise various modifications of the present invention without departing from the spirit and scope of the appended claims.